CITY WATERWAY BRIDGE
(11th Street Bridge)
(Thea Foss Waterway Bridge)
State Route 509, spanning the City Waterway
(the Thea Foss Waterway)
Tacoma
Pierce County
Washington

HAER No. WA-100

HAER
WASH
27-TACO,
9-

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

PHOTOGRAPHS

REDUCED COPIES OF MEASURED DRAWINGS

HISTORIC AMERICAN ENGINEERING RECORD
NATIONAL PARK SERVICE
DEPARTMENT OF THE INTERIOR

HAER
WASH
27-TACO,
9-

HISTORIC AMERICAN ENGINEERING RECORD

CITY WATERWAY BRIDGE
(11th Street Bridge)
(Thea Foss Waterway Bridge)

HAER No. WA-100

Location:	State Route 509, spanning the City Waterway (the Thea Foss Waterway), Tacoma, Pierce County, Washington, beginning at mile point 0.22. UTM: 10/542720/5233290 10/543240/5233380 Quad: Tacoma North, Wash.
Date of Construction:	1913
Engineer:	Designed by Waddell and Harrington, Kansas City, Missouri.
Fabricator:	Machinery and metal work by American Bridge Company. Substructure and erection by International Contract Company of Seattle.
Owner:	Originally built and owned by City of Tacoma. From 1957 Washington Department of Highways. From 1977 Washington State Department of Transportation, Olympia, Washington.
Present Use:	Vehicular and pedestrian traffic
Significance:	The City Waterway Bridge is an early example of a vertical lift bridge, designed by the renowned firm of Waddell and Harrington. Three features made it remarkable, if not unique among vertical lift bridges of the day: the unusually great height of the deck above the water; the employment of an overhead span designed for carrying a water pipe, and the fact it was built on a grade.
Historian:	Jonathan Clarke, August 1993.

History of the Bridge

The City Waterway Bridge today remains as the sole survivor of a group of at least three movable bridges which were built across the City Waterway, Tacoma, in the first decades of the twentieth century.[1] All fulfilled a vital role in Tacoma's industrial and commercial expansion, their construction signaling a new era of activity following a period of initial growth. Two of these, the Puyallup River Bridge and the City Waterway Bridge, were both municipally inspired, designed to provide essential infrastructural links between a commercial and industrial district divided by water. It was the City Waterway Bridge however that was particularly significant at the time of its construction, for two reasons. In terms of urban planning, it was the most important city project in 1913.[2] In terms of bridge engineering, three features made it remarkable, if not unique among vertical lift bridges of the day: the unusually great height of the deck above the water, the employment of an overhead span designed for carrying a water pipe, and the fact it was built on a grade.[3]

Tacoma had evolved into a thriving industrial center in the 1870s. Stimulated by the completion of the western end of the Northern Pacific Railroad linking Kalama to Tacoma in December 1873, it was able to exploit the rich natural resources of its hinterland. Besides the already established lumbering industry, coal mining became a major concern; the collieries that opened in Wilkeson two years later were producing some 100-150 tons of coal daily following the completion of a spur railroad line in 1878. With its enormous coal bunkers lining the bayside, Tacoma became the most important coaling station on the Pacific Coast. Increased profits facilitated new financing, and other industrial concerns, including a flour mill, a salmon cannery, and machine shops quickly arose.[4]

The late 1880s saw a further acceleration to Tacoma's industrial development. New land, ripe for expansion, was provided by a massive program to reclaim the tideflats on the eastern side of the city. This was quickly colonized by warehouses, flour mills, and grain elevators as Tacoma eclipsed Portland as the major processor and regional distributor of eastern Washington wheat. The lumber industry increased output considerably in response to both the new markets the railroads were opening up and the massive demand they placed for ties. The St. Paul and Tacoma Company was organized, purchasing some 80,000 acres of timberland and by 1887 Tacoma was producing some 87-million board-feet of lumber. Both ship and rail transportation were improved before the close of the decade; the former by the construction of further docks and the latter by the completion of the Stampede Pass Tunnel and the Northern Pacific's establishment of general offices in the city. Thus Tacoma, by this stage, was a major port with a strong industrial sector, able to service the increasing numbers of steamships and sailing vessels that docked there.[5]

It was against this backdrop that the city of Tacoma initiated the construction of a movable bridge with a 250′ swing span across a long narrow arm of Commencement Bay at the line of 11th street, which separated the city from the valuable, growing tideflats. However, great debate and discussion over the proposed width and length of the span impeded progress, and it was not completed until 1894.[6]

The contract for construction was awarded to the King Bridge Company, Cleveland, Ohio. The bridge was built as a composite iron and steel structure, consisting of two fixed spans of approximately 185′ and a swing span of 250′. The west approach was an iron viaduct 340′ long, comprised of a plate girder span of 60′ and a plate girder skew span of 64′. The east approach, a pile trestle, was constructed by the St. Paul and Tacoma Lumber Company.[7]

The swing span pivoted around a wrought-iron cylinder 34′ in diameter, filled with concrete, and penetrating down to a depth of about 22′ below low water. It was powered by the municipal electricity supply. The bridge deck, 22′ wide between trusses and flanked on either side by a 6′ walk, carried a double track street railway with a gauge of 3′-6". The total cost of the bridge, including approaches, was approximately $100,000.[8]

The operation and tendering of the bridge in the years following its construction became the "subject of much indignant discussion," principally because of the lengthy delays experienced by the owners of steamers and tugboats attempting to pass through the channel. The matter came to a head in December 1902, when several of the owners of these vessels, incensed by the latest incidence of excessive waiting, filed a protest with the city engineer.[9] In the same month a casting in the bridge broke. The importance of maintaining traffic flow on the bridge and in the channel dictated continued operation of the swing until the new part was made, even though it was liable to jam at any time.[10] Unfortunately, information regarding the outcome of these events was not secured, but no major structural alteration to the swing span seems to have been effected.

Efficiency of operation was all the more vital in the early years of the new century because of the steady increase in the volume of traffic, both water and vehicular, that accompanied Tacoma's expansion as a port. Great changes to the navigation and docking facilities, including the provision of modern, municipally owned docks and the creation of the City Waterway by the Corps of Engineers, started in 1902 and completed in 1905, resulted in a sizeable port equipped to serve the continued expansion of the city's commerce. The City Waterway project transformed the narrow arm of commencement Bay into what is the shallowest of Tacoma's six navigable basins: a 500'-wide ship channel, having for most of its length a minimum depth of water at low tide of 25'. Between Eleventh Street and Fourteenth Street the channel was dredged to a depth of 18', and beyond Fourteenth Street it gradually narrowed to a width of 250'.[11]

It was in this context of municipally inspired development that the city decided to replace the swing bridge with a larger, more reliable and efficient movable bridge. The old bridge was simply too low in terms of clearance, troublesome and outmoded to meet the demanding traffic requirements of a new era of commerce. The scale of investment in the new structure was enormous. At a cost of $600,000 it was some six times greater than the bridge it superseded.[12]

The engineering firm selected to prepare plans and specification for the new bridge was Waddell and Harrington of Kansas City, Missouri, which after only five years of partnership had, by 1911, already established itself as the leading firm in the design of vertical lift bridges. Their choice of design for the new bridge--a vertical lift--was not arrived at immediately however. One preliminary design was for a single-leaf bascule bridge, comprised of a 286' riveted Pratt draw flanked by two 160' and 190' fixed riveted Pratt truss spans on the east and west sides of the bridge respectively. The movable span and trusses were to rest on four concrete piers, whose form and disposition relative to the superstructure was very similar to that for the vertical lift design adopted, except that the eastern inner pier was to be used to support the trunnion of the bascule. The west approach, a steel-girder and column viaduct of double deck construction, providing an upper and lower roadway across the bridge and to the municipal dock respectively, was to have been identical to that finally adopted. The form of the east approach under this scheme is not shown on the plan.[13]

Waddell and Harrington's decision to opt for a vertical lift as opposed to a bascule was almost certainly dictated by the economic superiority of this form given the governing site conditions. A vertical lift, for instance, would not have to raise to the same degree as a bascule would for low-masted craft because the clearance of the lift span when down is that much greater than a bascule anyway. Also, vertical lift bridges are more suitable than bascules where a large horizontal clearance is required, an important factor where large, frequently passing vessels are concerned. The towers, counterweights, and machinery are, for a given weight of moving span, independent of the length of this; in a bascule these two factors vary almost directly.[14] But perhaps most significantly was the need to accommodate a municipal water pipe to the tideflats. In a vertical lift this is simply and cheaply achieved by spanning the opening between the tops of the towers with a light truss; the accomplishment of this in a bascule would necessitate either the costly and laborious laying of submarine cables or the erection of special towers for carrying an overhead span.

The final design was structurally and operationally similar in some respects to John Alexander Low Waddell's first lift bridge, the Halstead Street Lift Bridge over the Chicago River at Chicago, Illinois which was completed in 1894. According to Pulver this ranked as "the first vertical lift bridge of any size and importance to be constructed in [the United States] country."[15] Both were of the type having two diagonally braced towers connected by an overhead span, with a lifting span (with no lifting deck) operated from operating-house placed on its center. In other respects however it was different--seventeen years of progress in the design of this bridge type almost inevitably resulted in a structure that was technologically more sophisticated. Electrical operation, arched overhead girders and curved rear columns at the tops of the towers, use of greater capacity electric motors (that precluded the use of water-tanks in overcoming any temporary unbalanced load), and riveted construction throughout are among the features that distinguished it from its early forbearer.

The mechanical operation of the lift span seems to have been based on a patent (#932,359) Waddell and Harrington filed on 31 August 1908.[16] This specified the use of independent pairs of ropes connected to paired drums mounted at either end of the span. One of the ropes of each pair would be attached to the top of one of the towers, while the other would be attached to the lower part of the same tower. The lift span, rather than the ground, supported the operating machinery. The operational sophistication of this design can probably be attributed to the mechanical engineering skill John L. Harrington brought to the partnership; according to one biographical account, so successful was Harrington in developing Waddell's basic design that it came to replace the bascule where wider channels were required for navigation.[17]

A notable feature regarding the whole project was the utilization of the 1894 swing span both to maintain vehicular and maritime traffic during construction, and to facilitate erection of the new bridge. A timber trestle was built parallel to the old structure, extending on the east from Cliff Avenue to the swing bridge, and on the west from the north end of the swing span to the tide flats. The swing span was then moved around to meet these temporary trestles, thus creating a temporary roadway that was not obstructive to ships. This arrangement "elicited the wonder of thousands of beholders" and the only interruption to traffic occurred when it was swung around initially, and later when the center panels of the lift span were being erected. The remainder of the bridge was dismantled to allow for the construction of the new one.[18] On completion of the vertical lift bridge in February 1913 the swing span and trestles were removed.

The contract for the bridge was let in the early summer of 1911 to the International Contract Company, Seattle, whose responsibility was the construction of the substructure and the erection of the superstructure.[19] The contract called for the completion of the bridge in one year. The president and chief engineer of this company, C. E. Fowler took general charge of the entire work, with the assistance of P. J. O'Brien, general superintendent of construction; J. W. Dawson, superintendent of foundations; and T. G. McCrory, resident engineer. The machinery and steelwork for the superstructure was furnished by the American Bridge Company at a cost of over $275,000; the concrete for the foundations and piers was supplied by F. T. Crowe and Company. For their part, the city of Tacoma was represented by Owen Woods, commissioner of public works, and W. C. Raleigh, city engineer, both of whom directed the construction. The whole project was supervised from beginning to end by Waddell and Harrington.[20]

The International Contract Company began work on the bridge substructure in July 1911, working continuously throughout the day and night using eight-hour shifts. The foundations for the four piers were first built by sinking cribs, made up of 12" x 12" fir timber and having an opening of 21' x 81', to a depth of 54' below high water. The material inside each was then excavated by means of the open dredging process. Foundation piles were then driven within the cribs, 200 for each of the two central piers and 150 for each of the two end piers. These were of special selected fir stock, having a large diameter (the tops having a diameter of 8" and above) and length of up to 125'. The piles were jetted into place to a maximum depth of 115' low water, two jets and a 40' follower being used to each stick.[21]

Considerable problems were experienced in driving some of the piles: those in pier No. 3 proved so difficult to drive that at one time it took a crew eight hours to drive just one pile.[22] Once the pile driving was completed, the cribs were filled and then pumped free of water, the bottom cleaned out, and the piles cut off where required, using the trimming for fill. Plain concrete of a mixture in the proportion of 1:2:3 was then poured to a depth of 30', so forming the pier bases.[23]

Four piers, of the Fowler patent type, were then built up on the 30' bases. These were carried up on self-supporting forms in layers of 4'-5' thickness. Plain concrete composed of Riverside Portland cement and Vashon sand, mixed in the proportion 1:3:5 by motor driven Ransome machines, was used in their construction. Some 12,000 cubic yards of the material was used in total. Like the pile driving, this operation was similarly plagued by difficulties: one of the piers had to be taken up and reset four times before the correct position was obtained.[24]

Despite a four-month delay because of the non-arrival of steel work, the rest of the project progressed rapidly.[25] The erection of the plate girder viaduct forming the west approach, and the two fixed spans was accomplished routinely, the latter being erected on falsework (using mostly 12" x 12" Douglas fir as the principal members) by a boom derrick travelling on the roadway platform. In early October 1912 construction of the falsework or high bents for building the towers of the lift span was begun.[26] The tower posts were shipped direct from the shop in two sections and spliced in the middle at the site.[27] The towers completed, erection of the lift span proper was begun. An ingenious system of building two cantilever brackets was employed which enabled erection at an elevation of 120', thus maintaining navigation of the waterway and operation of the old swing bridge. These brackets were made up of three wooden bents, each of which corbelled out from the pier tops and was tied back to either end of the adjacent towers. Each bent was then used to erect one panel point of the lift span. Two other points were assembled using false work erected from the central pier of the old swing bridge. A final (ninth) panel point, the fourth from the west end, was erected on wire cables supported by the vertical members of the span truss previously riveted in place on either side of this point. The cables used in this operation were controlled by turn buckles, which permitted precise positioning of the members for riveting. Once the lift span trusses were self-supporting, the falsework on the swing span was removed, thus freeing it for its intended function.[28] With the lift span in the raised position, the machinery was placed in position, necessary adjustments were made and the deck was paved using wood blocks supplied by the St. Paul and Tacoma Lumber Company. The last structural component to be built was the overhead truss span connecting the towers, designed to carry a 16" water main to the tide flats. This was erected by a wooden tower traveller moving on the top chords of the lift span when it was in its highest position. After this was accomplished, the entire steel work was finished with two coats of Patterson-Sargent Company's black "Nobrac" paint.[29]

The bridge was ready for traffic on Saturday February 15, 1913, the official day of opening. The occasion was a truly momentous one in Tacoma's history, making front page news in the *Tacoma Sunday Ledger*. From a raised platform erected on the west end of the lift span, local dignitaries, and officials involved in the project, delivered speeches to a rapturous crowd of 10,000 people assembled on the west span and approach. The City Mayor, W. W. Seymour opened his address by remarking on the significance of the bridge:

> We of Tacoma should be proud of this grand structure. It is the widest of its type, one of the highest and the only one in America built on a grade.

The Secretary of the Commercial Club & Chamber of Commerce, T.H. Martin explained the importance of the bridge in terms of Tacoma's progress in industry:

> Nothing has been done for years that means as much to the industrial development of Tacoma as the building of this highway to the tidelands. In a few months we will be called upon to formally open another link in the road across the flats. Tacoma needs, above all, acreage sites for industries near deep water, and the tideflats is the only place where this can be had. I would like to see painted across the broad sides of the concrete weights, "Tacoma sells electric power cheaper than any city in the world". I will suggest this to the commercial club and I believe it should be done.

At the conclusion of the addresses, which began in the early afternoon, the lift span was raised to its full height before being lowered again to be dashed with a bottle of champagne. As the bottle broke, Miss Enola F. McIntyre, a local student, declared the bridge open, speaking the words "Tacoma High" for the name of the bridge. Interestingly, the bridge had already been unofficially dubbed "Eleventh Street", at least by the *Tacoma Daily Ledger*, and for the next few months the paper was to launch a long-running competition to find the most suitable name for the bridge. The editors of the paper, inundated with suggestions, waited until April before deciding upon the geographically logical yet already favored name of Eleventh Street Bridge. Waddell however called it the City Waterway Bridge.[30]

The whole event ran smoothly, although a hectic scramble occurred when hundreds of carnations were thrown from an upper railing and when President C. E. Fowler of the International Contract Company distributed free cigars by the handful to the crowd. Fowler claimed it "was the greatest bridge-opening ceremony [he] ever saw."[31] The event was of such contemporary significance that two motion picture interests, one of whom was Pathe Company, a major Hollywood studio at the time, each sent a camera operator to film the event for newsreels.[32]

Within a few days of the bridge ceremony, Martin's wish was realized, although not to the letter: the words "Municipal Light and Power: Cheapest in the U.S." were painted on the outer broadsides of the concrete counterweights.[33] The goodwill of March 15 did not follow through in all respects however. Some seven months afterwards, the International Contract Company had not fulfilled its final contractual obligation, the removal of the concrete pier of the old swing span to a depth of 29' below mean low tide. The city had specified this because of its intentions to dredge the channel to a greater depth. Forced into decisive action, the city withheld $6,000 for a short time whilst the work was completed.[34]

Built at a time of considerable expansion of Tacoma's industrial and commercial base, the City Waterway Bridge proved vital in providing access for workers to the tideflats' sawmills, factories, and railway shops and terminals. A similar function was served by the shorter, narrower Puyallup river vertical lift bridge that was built about a mile north of the City Waterway Bridge, in the same year. The lower deck of the west approach was used by hundreds of people each day to reach the municipal dock and its steamer service to Seattle.

The importance of the bridge to the tidelands remained strong, as Tacoma's progress in industry continued. Post-Second World War developments in chemical and electro-chemical industries, further provision of deep-water shipping facilities, and continued prosperity and growth of the forest-products industries ensured the relevance of the bridge in this context until fairly recently.[35]

Indeed, until the late 1940s, and probably later still, workers travelling across the bridge to and from the tideflats were given priority over shipping. In the morning, between 6:45 and 7:45, the lift span would not raise for any ship, and in the afternoon, between 3:45 and 5:00, it would go up only for ships over 700 tons.[36] Today, following Tacoma's decline as a port, the situation is much the reverse, and the span raises only a few times a month.[37]

Design and Description

The City Waterway bridge now consists of a 214' vertical lift span flanked by two 189' fixed spans which in turn are flanked by two approach spans, giving a total length of 1,747' - 5". The entire structure is built on a grade which varies across its length. At the time of it's construction this feature made it unique among vertical-lift bridges. From the start of the western approach to the third pier, the east end of the lift span, the grade is 2.57 percent. From that point to the fourth pier the grade continues on at 4 percent, and from the fourth pier to the tide flats the grade is 5 percent.[38]

The west approach span consists of approximately 100' of reinforced concrete retaining wall and a 575' plate steel girder double-deck viaduct consisting of alternate tower spans and connecting spans, ranging from 40' to 87.5' long, supported on vertical columns spaced 18.5' apart in three longitudinal rows. It was designed to provide both an upper roadway and sidewalks for traffic across the bridge, and a lower roadway and sidewalk for workers to the municipal dock. This dock was located immediately north of and adjacent to the viaduct. The upper roadway section of the viaduct slopes upwards on a grade of 2.576 percent from the shore span to a clearance above a track of the Northern Pacific Railroad lines on what was formerly Cliff Avenue. From that point it slopes downwards to the ground on the bluff, where it turns 180 degrees and runs parallel to the bridge axis on a steep (8 percent) down grade, thus forming the lower roadway. The roadway on this lower section is 19'-4" wide, and the sidewalk is 10'. At the shore pier it reverses direction again, continuing downwards on a sharp incline.[39] Until the 1960s, when road construction necessitated removal of the end section, it extended to the level of the railroad tracks and Cliff avenue. The east approach was originally formed by a timber trestle over 1100' long. It was removed in 1951 and replaced by a reinforced concrete ramp which was completed in 1954.[40]

The four piers that support the truss spans are each made up of a pair of conical shafts, varying in height between 72' and 90', connected throughout their height by reinforced concrete webs. Each is aligned perpendicular to the axis of the bridge. This Fowler patented construction had the advantage of reducing both the load on the pile foundations and quantity of material required.[41]

The three central spans--the bridge proper--consist of two seven-panel and one eight-panel riveted steel Pratt trusses. Structurally, the movable span is almost identical to the fixed spans, the only significant differences being provision for the attachment of the sustaining and hoisting cables, guide rollers, etc. Each of the fixed spans is equipped with a steel tower composed of two vertical front and two inclined rear columns, thoroughly braced in both directions. The bases of the vertical front columns are fitted inside shoes which rest on the two inner piers whilst the rear columns are supported by the fixed truss. Two enormous cast-steel sheaves are mounted directly over the tops of the tower columns, which support almost the entire load. Each of the four steel sheaves is 9'-4" in diameter and mounted upon 16" axles.[42]

Between the tops of the opposite towers is a light aluminum truss which functions both in carrying nine electrical transmission lines from the city to the tidelands, and in maintaining the correct position of the towers. It was erected in 1969 and replaced the original connecting truss, a public service span which carried a 16-inch water main from the city to the tide flats. This water pipe was carried from the ground up the outer piers, along the top chord of the trusses of the fixed spans, up the back of the towers and over the light connecting truss. The three truss spans support a 50' roadway and two 10' sidewalks, which are carried on cantilever brackets. The deck is now built up of reinforced concrete, but originally it consisted of 6" x 9" creosoted stringers supporting 4" plank. Creosoted wooden paving blocks, supplied by the St. Paul & Tacoma Lumber Company, formed the road surface. This former roadway, in addition to providing for highway traffic, also carried a double-track street railway owned by the city.[43]

The most remarkable aspect of the bridge is the design and operation of the lift span. The span is suspended at its four corners by 16 plow-steel wire ropes which pass over the sheaves at the tower tops and connect to two concrete counterweights hanging inside the towers. Each of these counterweights measures 6'-6" by 17'-3" by 50'-9" long.[44] They are constructed of plain concrete, poured about a steel frame. The great weight of each--400 tons--is necessary to balance the dead weight of the lift span and operating machinery. The ropes, which are 1-1/2" in diameter, are connected to the counterweights through a system of pin-connected equalizing levers. These serve to adjust the tension in each rope, thus ensuring that the load is equally distributed over each group of sixteen ropes. The other ends of the counterweight cables are attached directly to the portal struts of the lift span.[45]

Because the gravitational pull on the lift span is effectively offset by counterweights, the span is able to be pulled up and down through a system of ropes and pulleys. Four grooved hoisting drums are fixed on the center of the span, two on either top chord. Each drum carries two plow-steel ropes, one of which runs underneath a small sheave on the corner of the span and is fixed to the top of the span, while the other runs over the same sheave and connects to the bottom of the tower. All four drums are similarly connected, each to its respective corner. The drums are rotated by two 75 horsepower direct current

Westinghouse motors of the street-railway type, which work through a set of gears, and are located in the motor house on the top chord of the span, between the hoisting drums.[46] When the drums are rotated so that the ropes connecting the truss to the towers are wound up, the span is raised. As this happens, because the "up" rope and "down" rope are wound around each drum in opposite directions, the ropes leading to the bottom of the towers are simultaneously paid off in equal measure. Reversal of the direction of rotation of the drums lowers the span.

The motion of both the span and counterweights is steadied whilst they ascend and descend. The counterweights travel along guide - frames made up of 3" angles, fixed to the inside of the tower posts. The span is steadied by two rollers at the tops and bottoms off each end post of the truss. Each pair consists of a vertical and longitudinal roller, but only the latter presses against the tower columns at all times. The longitudinal rollers are connected to springs, thereby allowing for any expansion or contraction of the truss. The vertical rollers only engage with the tower columns if the wind pressure is sufficient.

To maintain the balance between the lift span and the counterweights, concrete weights, each a cubic foot in size, were designed to be placed on either the counterweights or the span. An unbalanced situation may develop from the accumulation of snow, moisture, dirt etc. on the deck.[47] Each of the counterweights now support several of these concrete blocks. They were probably added in 1945 when the original timber deck was replaced by the heavier steel and concrete equivalent.

One of the significant features of this bridge compared to other vertical lift bridges at the time of construction was the unusually great height that the span could be raised to. At its highest position, the clearance between the lower chord and the water at high tide was 135′. When the span is fully lowered it is 60′ above water level, providing a horizontal clearance of 200′. With the motive power operating it, the movement of the span in either direction, a distance of 75′, takes 30 seconds. This equates to a speed of approximately two miles per hour. The span is automatically brought to rest when it reaches its upper or lower limits of travel, since the electric current is broken automatically and solenoid brakes are applied. A hand brake is also provided as a safeguard.[48] This sophisticated method of braking marks an advance over some earlier vertical bridges using steam as the source of motive power. It obviated the need for hydraulic buffers or steel springs, although on some electrically operated spans these were still provided as a safeguard.

The draw span was designed so that it could also operate manually, should there be a malfunction with the motive power. A low-geared capstan, located in front of the operating house, enabled the bridge tender to do this. By this method, the bridge was fully raised or lowered in about three and a half hours.[49] The capstan cannot be operated now, because the replacement of the original operating house with a smaller one has obstructed its working space.

At either end of the fixed spans, next to the lift span, were two gates sets of gates, electrically controlled from the operator's cabin. These gates, two at either end, were simultaneously lowered and swung across the roadway to stop the traffic. When this occurred, a bell automatically rang at both ends of the lift span, warning traffic that it was about to be raised.[50] Now the gates can only be moved by hand.

Repair and Maintenance

Significant modifications have been effected to the City Waterway Bridge in the 80 years since it was built. During the early 1940s, the bridge carried the major burden of traffic to and from the extensive war industries that occupied much of the tideflats. As a result, the wood and asphalt deck of the lift span and side spans suffered excessive wear, and in May 1945 the City decided upon its replacement. It was re-decked with lightweight concrete by the General Construction Company, Seattle. The cost of this, some $167,000, was met equally by both the city of Tacoma and a grant from the Federal Works Agency.[51]

By September 1951 the deck and posts of the east timber approach were seriously deteriorating,[52] and in 1952 these were replaced.[53] In the same year work began on the construction of a 788' concrete ramp from Tenth and A streets, on the west side of the bridge. This was intended to divert traffic directly off Eleventh street and into Tenth street, where it would be more efficiently channeled north and south via A Street or Pacific Avenue.[54] Prior the building of this ramp, which was completed in March 1954, rush hour bottlenecks of traffic, causing lines of traffic for three fourths of the length of the bridge, were a frequent problem.[55]

In July 1954, work started on the construction of an 892' concrete approach to the east end of the span, replacing the timber trestle. Consisting of nine pre-stressed girder spans, each 75' long, and a filled retaining wall abutment, it was reputedly the first large structure to be built by the state using pre-stressed concrete piling and girders. This technique allowed construction of one half of the new approach in pieces, whilst the other half of the old approach remained standing, thus maintaining traffic flow.[56]

The steel truss connecting the two towers was removed by Roy T. Early Construction Company on June 12, 1963. The water main it carried had for not been used for several years, and the truss was removed to ease the load and stresses on the bridge.[57] It was replaced by a light aluminum truss in about 1969 that was designed to carry electrical power transmission lines to the industries on the tideflats.[58] In 1974, four steel beams were altered. Details of these are not specified, but their dimensions were recorded as being 3'-11"; 47-0"; 16'-0" and 21'-0".[59]

The lift is still in operation, and its mechanical and electrical systems are in good overall condition. Washington State Department of Transportation inspections of the trusses show that all elements are in good condition, except for the bottom chords and gusset plates. A recent report on the bridge concluded that "after rehabilitation, with proper maintenance there is no reason to doubt that the trusses, floor beams and stringers could provide adequate service for another 70 years."[60]

Data Limitations

At least four engineering articles were written about this bridge in the period 1912-14. It also received mention in Waddell's own book, *Bridge Engineering* (see bibliography).

The construction of the bridge also generated considerable media interest, mostly from the *Tacoma News-Tribune*. The Tacoma Public Library has a comprehensive clipping file and card index of citations for the bridges of Tacoma. This provided the great majority of newspaper articles.

The City Public Works engineering department of Tacoma was not consulted because it was ascertained that the majority of information regarding the bridge at this location was duplicated by that held at the Bridge Preservation Section, Washington State Department of Transportation, Olympia. This latter place has extensive records on the operation and maintenance of movable bridges owned by the state, located in its movable bridges files.

Project Information

This project is part of the Historic American Engineering Record (HAER), National Park Service. It is a long-range program to document historically significant engineering and industrial works in the United States. The Washington State Historic Bridges Recording Project was co-sponsored in 1993 by HAER, the Washington State Department of Transportation (WSDOT), and the Washington State Office of Archeology & Historic Preservation. Fieldwork, measured drawings, historical reports, and photographs were prepared under the general direction of Robert J. Kapsch, Ph.D., Chief, HABS/HAER; Eric N. DeLony, Chief and Principal Architect, HAER; and Dean Herrin, Ph.D., HAER Staff Historian.

The recording team consisted of Karl W. Stumpf, Supervisory Architect (University of Illinois at Urbana-Champaign); Robert W. Hadlow, Ph.D., Supervisory Historian (Washington State University); Vivian Chi (University of Maryland); Erin M. Doherty (Miami University), Catherine I. Kudlik (The Catholic University of America), and Wolfgang G. Mayr (U.S./International Council on Monuments and Sites/Technical University of Vienna), Architectural Technicians; Jonathan Clarke (ICOMOS/Ironbridge Institute, England) and Wm. Michael Lawrence (University of Illinois at Urbana-Champaign), Historians; and Jet Lowe (Washington, D.C.), HAER Photographer.

SELECTED BIBLIOGRAPHY

Journals:

"Lift Bridges Compared With Other Movable Forms: An Analysis of Their Relative Advantages and a Detailed Study of the Vertical Moving Types." *Railway Age* 70 (17 June 1921): 1391-94.

"Small Vertical-Lift Drawbridges." *Engineering News-Record* 68 (18 July 1912): 99-101.

"Some Features of the Design and Construction of the City Waterway Bridge at Tacoma, Wash." *Engineering and Contracting* 41 (11 March 1914): 311-12.

"The City Waterway Bridge, Tacoma, Washington." *Engineering News 69* (1912): 1010.

"The Eleventh Street Steel Bridge, Tacoma." *Engineering-Contracting Number* (12 April 1913): 232-34.

"Vertical Lift-Span Highway Bridge in Tacoma." *Engineering Record* (19 April 1913): 428-29.

Waters. Charles R. "A Lift Bridge Constructed on 4 Per Cent Grade.". *Engineering News* 73 (15 April 1915): 705-06.

Books:

Corning, Howard McKinley, ed., *The New Washington: A Guide to the Evergreen State*. Revised ed. American Guide Series. Portland: Binfords & Mort, 1950.

Pulver, H. E. "Vertical Lift Bridges." In *Moveable and Long-Span Steel Bridges*, ed. George A.Hool and W.S.Kinne, 158-79. New York: McGraw-Hill Book Company, Inc., 1924.

U.S. Department of the Interior. National Park Service. *Tacoma: The Union Depot District*. Washington: Government Printing Office, 1981.

Waddell, J. A. L. *Bridge Engineering*. Vol. 1. New York: John Wiley & Sons, Inc., 1916.

Newspapers: Pre-Construction & Construction History:

"Bridge Naming Contest Ends; Prize of $25 Will Be Awarded." *Tacoma Daily Ledger*, 16 March 1913.

"Bridge Contract Completed at Once." *Tacoma Daily Ledger*, 28 December 1913, 4.

"Bridge is Joined from End to End." *Tacoma Daily Ledger*, 24 November 1912.

"$25 For Name of New Bridge." *Tacoma Daily Ledger*, 16 February 1913, 1.

"$25 For Most Appropriate Name For New Bridge." *Tacoma Daily Ledger*, 2 March 1913, 11.

"10,000 Attend Bridge Opening." *Tacoma Daily Ledger*, 16 February 1913, 1.

"Cost of City Improvements In 1913 Reaches Huge Total." The *Tacoma Daily Ledger*, 25 January 1914.

"Eleventh Street Bridge is Broken." *Tacoma Daily Ledger*, 19 December 1902, 3.

"Engineers's Drawings Illustrating 11th Street Bridge Problem." *Tacoma Daily Ledger*, 12 November 1911.

"False Work Erected for Lift Span of Bridge Connecting Tacoma With Big Factory District." *Tacoma Daily Ledger*, 13 October 1912, 19.

"Huge Bridge Gives Accessibility to Tideflats." *Tacoma Daily Ledger*, 19 February 1913.

"How It Can Be Done: Three Things Necessary Before Eleventh Street Bridge Can Be Built." The Tacoma Daily Ledger, 30 August 1893, 5.

"Many Bridge Names Yet Remain for Consideration." *Tacoma Daily Ledger*, 22 March 1913, 11.

"New Traffic Artery to Waterfront." *Tacoma Daily Ledger*, 15 February 1914, 23.

"Naming the New Bridge." *Tacoma Daily Ledger*, 19 February 1913.

Ripp, Bart. "A span of history." *Tacoma Morning News-Tribune*, 15 December 1991, 9-11.

"Some Persons Not Aware That Bridge Naming Contest Ended March 15." *Tacoma News-Tribune*, 23 March 1913, 27.

"Steamer Captains Complain of Delay at Eleventh Street Drawbridge." *Tacoma Daily Ledger*, 16 December 1902, 3.

"Tacoma Offers Most Advantageous Site for Numerous Industries" *Tacoma Daily Ledger*, 19 February 1913.

"Tacoma's $600,000 Bridge Ready Today." *Tacoma Daily Ledger*, 2 February 1913.

"Tacoma Soon to Be One of World's Greatest Commercial Centers." *Tacoma Daily Ledger*, 2 March 1913, 20.

"The New Eleventh Street Bridge." *Tacoma Daily Ledger*, 20 May 1894, 2.

"The City's Plans Approved. Eleventh Street Bridge Draw Span Will Not Have to Be Moved." *Tacoma Daily Ledger*, 28 November 1893, 6.

"Remarkable Progress." *Tacoma Daily Ledger*, 19 February 1913,

"View Showing Work Erecting Middle Span of Tacoma Bridge." *Tacoma Daily Ledger*, 3 November 1912, 19.

Post Construction History:

"A Re-Volting Development." *Tacoma News-Tribune*, 21 January 1966. Tacoma Public Library Clipping File [TPL:CF].

"Bids on Bridge Ramp Opened." *Tacoma News-Tribune*, 16 March 1955. [TPL:CF]

"Big bridge parts return earthward." *Tacoma News-Tribune*, 24 June 1979. [TPL:CF]

"Bridge At 11th Street To Be Closed." *Tacoma News-Tribune*, 11 June 1963. [TPL:CF]

"Bridge Comes Down . . . 19 Hours Later." *Tacoma News-Tribune*, 13 September 1969. [TPL:CF]

"Bridge over City Waterway will be closed." *Tacoma News-Tribune*, 21 August 1978. [TPL:CF]

"Bridge Truss Lowered." *Tacoma News-Tribune*, 29 September 1966. [TPL:CF]

"Bridge Truss To Leave Skyline." *Tacoma News-Tribune*, 25 September 1966. [TPL:CF]

"Bridge Jump Brings Death." *Tacoma News-Tribune*, 10 May 1954. [TPL:CF]

"Bridge Ramp To Be Opened Soon." *Tacoma News-Tribune*, 15 February 1954. [TPL:CF]

"Bridge Tender Has Anecdotes." *Tacoma Daily Ledger*, 1 February 1935. [TPL:CF]

"City hopes to save six historic bridges." *Tacoma News-Tribune*, 6 June 1990. [TPL:CF]

"Concrete To Redeck Span." *Tacoma News-Tribune*, 17 May 1945. [TPL:CF]

"Council Votes To Have Bridge Design Started." *The Tacoma Star*, 15 May 1952. [TPL:CF]

"Development under 11th Street Bridge proposed by architect." *Tacoma News-Tribune*, 27 April 1983. [TPL:CF]

"Enlist State Aid on Stuck 11th St. Bridge." *Tacoma News-Tribune*, 13 August 1954. [TPL:CF]

"11th Street Bridge Cut-Off." *The News Tribune*, 22 November 1953. [TPL:CF]

"11th Street Bridge options to be aired." *Tacoma News-Tribune*, 16 March 1979. [TPL:CF]

"11th St. Bridge Gets Stuck Up And Traffic Hits Mammoth Snarl." *Tacoma News-Tribune*, 12 September 1969. [TPL:CF]

"11th St. Span On Schedule." *Tacoma News-Tribune*, 1 October 1952. [TPL:CF]

"17-Year-Old Ruston boy dives 90 feet from the 11th Street bridge to waterway." *Tacoma Daily Ledger*, 6 February 1927, A7.

"Ker-Whoom!" *Tacoma News-Tribune*, 19 May 1957. [TPL:CF]

"Landmark Removed." *Tacoma News-Tribune*, 13 June 1963. [TPL:CF]

"Lift bridge to get lower look." *Tacoma News-Tribune*, 26 April 1979. [TPL:CF]

"Must Move City Bridges." *Tacoma News-Tribune*, 22 April 1946. [TPL:CF]

"New Bridge Held Link To Tacoma's Future." *Tacoma News-Tribune*, 17 May, 1964. [TPL:CF]

"Nuisance Space At Bridge Will Be Eliminated." *Seattle Times*, 28 May 1941. [TPL:CF]

"Off Ramp Progressing." *Tacoma News-Tribune*, 20 December 1953. [TPL:CF]

"'On-Ramp' to A Street Eyed by City Council." *Tacoma News-Tribune*, 16 March 1960. [TPL:CF]

"Out of Tacoma's Past . . . " *Tacoma News-Tribune [?]*, 13 May 1962. [TPL:CF]

"Ramp Opens." *Tacoma News-Tribune*, 6 March 1954. [TPL:CF]

"Ramp Ready On Thursday." *Tacoma News-Tribune*, 2 March 1954. [TPL:CF]

"Rush Clearing of Debris For Opening of Ea. 11th St.Span During Afternoon." *Seattle Times*, 17 November 1947. [TPL:CF]

"Sailor risks life by diving 120 feet from top of 11th St.Bridge." *Tacoma Daily Ledger*, 4 November 1929, 1.

"Spent 38 Years in Drawbridge Penthouse." *Tacoma Daily Ledger*, 4 April 1948. [TPL:CF]

"Start Bridge Repair." *Tacoma Daily Ledger*, 6 April 1952. [TPL:CF]

"State to Open Bridge Bids." *Tacoma News-Tribune*, 3 October 1957. [TPL:CF]

"Tideflats bridge foils rush-hour motorists." *Tacoma News-Tribune*, 25 August 1987. [TPL:CF]

"Traffic Ramp Bids Await Easement." *Tacoma News-Tribune*, 3 June 1953. [TPL:CF]

"We Made the Approach Too Long, State Highway Engineers Moan." *Tacoma News-Tribune*, 18 August 1957. [TPL:CF]

"Weekend closure slated for 11th Street bridge." *Tacoma News-Tribune*, 3 February 1977. [TPL:CF]

"Wide stroll up the City Waterway." *Tacoma News-Tribune*, 7 May 1978. [TPL:CF]

"Woes in Wake Of New Ramp." *Tacoma News-Tribune*, 29 March 1954. [TPL:CF]

"Work to close 11th Street." *Tacoma News-Tribune*, 26 May 1979. [TPL:CF]

Biographies: J. A .L. Waddell and J. L. Harrington

Edwin Layton. *Dictionary of American Biography*, Supplement Three 1941-1945, ed. Edward T. James, 331-32. New York:Charles Scribner's Sons, 1945, 331-332.

"John A. L. Waddell, A Bridge Engineer." *New York Times*, 3 March 1938.

Miscellaneous:

Patent No. 932,359. Filed 31 August 1908 by John A. L. Waddell and John L. Harrington, Kansas City, Missouri. Serial No. 450,944. In *Official Gazette of the United States of the United States Patent Office*, Vol. CXLV, August 1909. Washington: Government Printing Office.

WSDOT Historic Bridge Inventory. "11th St.Bridge--City Waterway." Held by Environmental Unit, Washington State Department of Transportation.

ENDNOTES

[1] The two other bridges (now dismantled) besides the Puyallup bridge, that spanned the City Waterway were swing bridges; one was built in 1914 by the American Bridge Company for the Union Pacific Railroad, crossing the waterway at Fifteenth Street, and the other was known as the Oregon-Washington Railway Bridge which was jointly owned by the Oregon-Washington Railroad and Navigation Company. See Department of the Interior, National Park Service, *Tacoma: The Union Depot District* (Washington: Government Printing Office, 1981; "Cost of City Improvements In 1913 Reaches Huge Total," *Tacoma Daily Ledger*, 25 January 1914.

[2] "Cost of City Improvements In 1913 Reaches Huge Total."

[3] J. A. L. Waddell, *Bridge Engineering* (New York: John Wiley & Sons, Inc., 1916), 1:734.

[4] Howard McKinley Corning, ed., *The New Washington: A Guide to the Evergreen State*, revised ed., American Guide Series (Portland: Binfords & Mort, 1950).

[5] Ibid.

[6] "How It Can Be Done: Three Things Necessary Before Eleventh Street Bridge Can Be Built," *Tacoma Daily Ledger*, 30 August 1893, 5.

[7] "The New Eleventh Street Bridge," *Tacoma Daily Ledger*, 20 May 1894, 2.

[8] Ibid.

[9] "Steamer Captains Complain of Delay at Eleventh Street Drawbridge," *Tacoma Daily Ledger*, 16 December 1902, 3.

[10] "Eleventh Street Bridge is Broken," *Tacoma Daily Ledger*, 19 December 1902, 3.

[11] Department of the Interior, National Park Service, *Tacoma: The Union Depot District*.

[12] "Tacoma's $600,000 Bridge Ready Today," *Tacoma Daily Ledger*, 2 February 1913.

[13] Preliminary design drawing by Waddell and Harrington, of the City Waterway Bridge [date unknown], held by Records Control, Washington State Department of Transportation, Olympia, WA [WSDOT].

[14] "Lift Bridges Compared With Other Movable Forms: An Analysis of Their Relative Advantages and a Detailed Study of the Vertical Moving Types," *Railway Age* 70 (17 June 1921): 1391-94.

[15] H. E. Pulver, "Vertical Lift Bridges," in *Moveable and Long-Span Steel Bridges*, ed. George A. Hool and W. S. Kinne (New York: McGraw-Hill Book Company, Inc., 1924), 158-79.

[16] Patent No. 932,359, filed 31 August 1908 by John A. L. Waddell and John L. Harrington, Kansas City, Missouri, serial no. 450,944, in *Official Gazette of the United States of the United States Patent Office* (Washington: Government Printing Office) vol. CXLV, August 1909.

[17] Edwin Layton, *Dictionary of American Biography*, supplement three 1941-45, ed. Edward T. James (New York:Charles Scribner's Sons, 1945), 331.

[18] "Huge Bridge Gives Accessibility to Tidalflats," *Tacoma Daily Ledger*, 19 February 1913.

[19] "The Eleventh Street Steel Bridge, Tacoma," *Engineering-Contracting Number*, 12 April 1913, 232.

[20] "Some Features of the Design and Construction of the City Waterway Bridge at Tacoma, Wash.," *Engineering and Contracting* 41 (11 March 1914): 312.

[21] "The Eleventh Street Steel Bridge, Tacoma," 232.

[22] "Huge Bridge Gives Accessibility to Tideflats."

[23] "The Eleventh Street Steel Bridge, Tacoma," 232-34.

[24] "Huge Bridge Gives Accessibility to Tideflats"; "The Eleventh Street Steel Bridge, Tacoma," 232.

[25] "Bridge is Joined from End to End," *Tacoma Daily Ledger*, 24 November 1912.

[26] "False Work Erected for Lift Span of Bridge Connecting Tacoma With Big Factory District," *Tacoma Daily Ledger*, 13 October 1912, 19.

[27] "The Eleventh Street Steel Bridge, Tacoma," 233.

[28] "Vertical Lift-Span Highway Bridge in Tacoma," *Engineering Record* (19 April 1913): 429; "Some Features of the Design and Construction of the City Waterway Bridge at Tacoma, Wash.," 312; "The Eleventh Street Steel Bridge, Tacoma," 233-34.

[29] "Some Features of the Design and Construction of the City Waterway Bridge at Tacoma, Wash.," 312.

[30] Bart Ripp, "A span of history," *Tacoma Morning News-Tribune*, 15 December 1991, 9.

[31] "10,000 Attend Bridge Opening," *Tacoma Daily Ledger*, 16 February 1913, 1.

[32] Ripp, "A span of history," 9.

[33] A photograph of the bridge in the *Tacoma Daily Ledger*, 19 February 1913, shows the counterweights painted with the words "Municipal Light and Power: Cheapest in the U.S."

[34] "Bridge Contract Completed at Once," *Tacoma Daily Ledger*, 28 December 1913, 4.

[35] Corning, *The New Washington: A Guide to the Evergreen State*, 271.

[36] "Spent 38 Years in Drawbridge Penthouse," *Tacoma Daily Ledger*, 4 April 1948. [TPL:CF]

[37] Jonathan C. Clarke, interview with bridge tender of City Waterway Bridge, July 1993.

[38] "The Eleventh Street Steel Bridge, Tacoma," 232-34.

[39] "Vertical Lift-Span Highway Bridge in Tacoma," 428-29.

[40] "City Waterway Bridge, No. 509/5," Bridge Inspection Reports, in Movable Bridge Correspondence Files, Bridge Preservation Section. WSDOT.

[41] "Some Features of the Design and Construction of the City Waterway Bridge at Tacoma, Wash.," 311.

[42] "The Eleventh Street Steel Bridge, Tacoma," 233.

[43] "The City Waterway Bridge, Tacoma, Washington," *Engineering News 69* (1912): 1010.

[44] "The Eleventh Street Steel Bridge, Tacoma," 232-34.

[45] "Some Features of the Design and Construction of the City Waterway Bridge at Tacoma, Wash.," 311-12.

[46] Ibid., 311.

[47] Waddell, *Bridge Engineering*, 1:734.

[48] "Tacoma's $600,000 Bridge Ready Today," *Tacoma Daily Ledger*, 2 February 1913.

[49] Clarke interview with bridge tender.

[50] "Tacoma's $600,000 Bridge Ready Today."

[51] Ibid.; "City Waterway Bridge, No. 509/5," Kardex Card File, Bridge Preservation Section, WSDOT.

[52] "City Waterway Bridge, No. 509/5," Bridge Inspection Report (12 September 1951), Bridge Preservation Section, WSDOT.

[53] "Start Bridge Repair," *Tacoma Daily Ledger*, 6 April 1952. [TPL:CF]

[54] "Off Ramp Progressing," *Tacoma News-Tribune*, 20 December 1953. [TPL:CF]

[55] "11th Street Bridge Cut-Off." *Tacoma News-Tribune*, 22 November 1953. [TPL:CF]

[56] "We Made the Approach Too Long, State Highway Engineers Moan," *Tacoma News-Tribune*, 18 August 1957. [TPL:CF]

[57] "Bridge At 11th Street To Be Closed," *Tacoma News-Tribune*, 11 June 1963. [TPL:CF]

[58] WSDOT Historic Bridge Inventory, "11th St.Bridge--City Waterway," held by Environmental Unit, WSDOT.

[59] WSDOT Historic Bridge Inventory; "City Waterway Bridge, No. 509/5," Kardex Card File, Bridge Preservation Section, WSDOT.

[60] A. G. Lichtenstein and Associates, Inc., Consulting Engineers, "City Waterway Bridge No.509/5 on SR509: Report on Rehabilitation Study, August 1988," for the Washington State Department of Transportation, Tacoma [*sic*], Washington, held by Bridge Preservation Section, WSDOT.